LABORATORY STUDIES ON THE LIFE CYCLE OF *SIMOCEPHALUS SERRULATUS* KOCH 1881 (CLADOCERA: CRUSTACEA)[1]

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(*With one plate*)

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The life cycle of the cladoceran *Simocephalus serrulatus* has been described on the basis of laboratory culture. The neonates produced from the same brood pouch may be all female, all male or both male and female. The female neonates pass through 3 preadult instars and 18 adult instars, while the males have only 2 preadult instars and there is no moulting in the adult stage. Egg production starts at the 4th instar. The maximum number of eggs is produced during 10th to 12th instars.

Introduction

The successful culture of Cladocera depends on our knowledge of the biology and life cycle of individual species.Several investigators have attempted to study the life cycle of a few species of Indian Cladocera. These include the works of Navaneethakrishnan and Michael (1971) on *Daphnia carinata*, Murugan and Sivaramakrishnan (1973) on *Simocephalus acutirostratus*, Murugan (1975a) on *Moina micrura*, Murugan and Sivaramakrishnan (1976) on *Scapholeberis kingi*, Murugan (1975b) on *Ceriodaphnia cornuta*, Murugan and Venkataraman (1977) on *Daphnia carinata*, Murugan and Job (1982) on *Leydigia acanthoceroides*, Kanaujia (1982) on *Ceriodaphnia cornuta*. Kanaujia (1983) on *Daphnia lumholtzi* and Kanaujia (1987) on *Simocephalus vetulus*. Recent study of Thresiamma *et al.* (1991) on the production and population density of *Moina micrura* is the only report on similar studies from Kerala. The above papers give good accounts of the life history of parthenogenetic females,but they do not give sufficient information about the role of males and ephippial females in the life cycle. The present study is a detailed investigation of the life cycle of *Simocephalus serrulatus*, a common cladoceran species of Kerala.

Material and Methods

Simocephalus serrulatus is a large cladoceran found among the littoral weeds and sediments of ponds. The specimens for the present study were collected from a shallow pond situated near Christ College campus and brought live to the laboratory. Twenty-five healthy, egg-bearing females were sorted out under a stereoscopic microscope and were transferred into an earthern pot of 5 litre capacity containing the culture medium. This was maintained as the stock culture. The culture medium was prepared in pond water and filtered through a net made of No. 25 bolting silk. Powdered groundnut cake (500 mg/l) was used as manure for growing algal cells. The medium contained mainly unicellular alga *Chlorella* sp. at a density of about 10 x 10^3 cells/l.

One ovigerous female was isolated from the stock culture with the help of a pipette and inoculated into a beaker containing 250 ml of the

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same culture medium. This female was kept under constant observation so as to isolate the newly hatched young neonates. They were individually reared in 20 different petri dishes containing the culture medium which was changed every 24 hours. The time of hatching and moulting, number of neonates hatched in each brood and the life span of all the individuals were regularly recorded until their death. The experiments were repeated thrice and mean values were taken. All observations were made at room temperature 27±2°C.

The ephippial females were also collected from the stock culture and isolated under the microscope. Free ephippia found in large numbers floating on the surface of the culture medium as well as sticking onto the sides of the container were easily collected with the help of a brush or a pipette. Another set of 5 individuals was simultaneously reared in the same medium for dissection, using microtungsten needle. Measurements were made with a calibrated ocular micrometer.

Observations

In the culture medium, the females were generally found clinging on to the side wall of the container with the help of their antennal hooks. They kept their body upside down while swimming. The males were found to be more active than the females, and always swimming in the medium. During mating, the male remained adhered to the hind end of the female. The mating behaviour is found to be similar to that of *Pleuroxus denticulatus*, as described by Shan (1969).

In the first set of experiments, out of the 20 neonates produced from a brood, 16 were found to be females and the rest males. The female neonates measured a mean length of 0.615 mm while males measured 0.55 mm. But in the second set all the neonates produced were males while in the third set all the neonates were parthenogenetic females. In addition to their smaller size, the males could also be distinguished by the presence of two sensory setae on the middle of the antennule and prehensile claws on the first thoracic leg. Unlike other daphnids, the antennule of the male is not elongated. The newly hatched young were found to be similar to the adults in morphology except for their miniature size. (Plate 1, Fig. 1).

The female neonates pass through 3 preadult instars and 18 adult instars in a life span of 35.8 days, with an average instar duration of 40.9 hours. The males, however, had only 2 preadult instars and there was no moulting in the adult stage. The average instar duration of a male was 56 hours with a life span of 6.5 days. The males matured after two moults. A pair of elongated testes extending over one-third of the length of the animal was distinctly visible at this stage. The mature males had a mean length of 0.675 mm (Plate 1, Fig. 2)

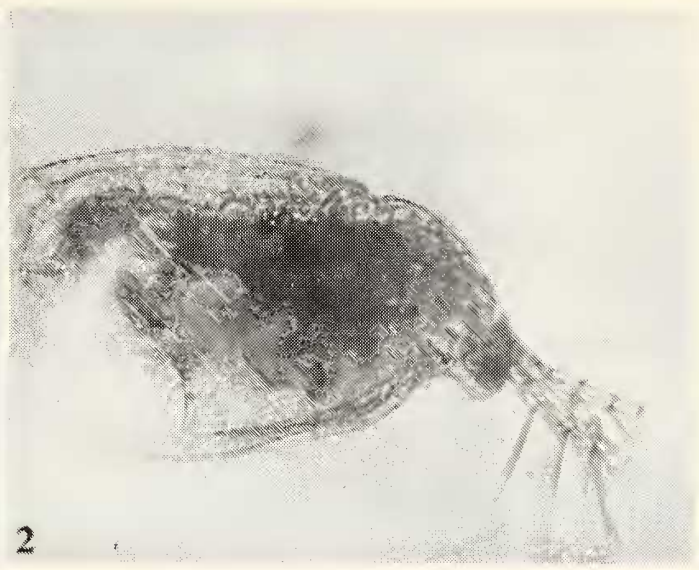
In mature females, the ovaries were seen as a pair of elongated sacs on each side of the alimentary canal. The contents of the ovaries were discharged through a small opening at the posterior end into the brood-pouch. This discharged mass later became spherical and formed the eggs. (Plate 1, Fig. 3). The relationship between mean size of each instar and the number of eggs produced from each brood, and instar duration are given in Table 1.

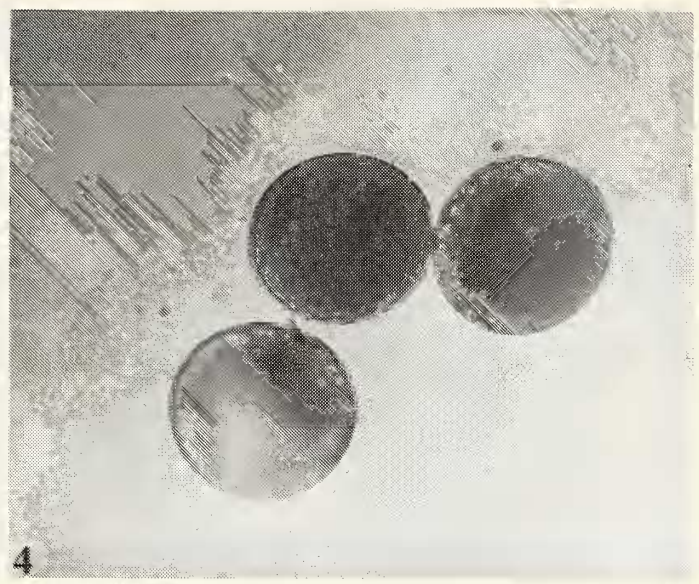
The morphological features of the embryonic stages of *S. serrulatus* are given below, following the terminology of Green (1966):

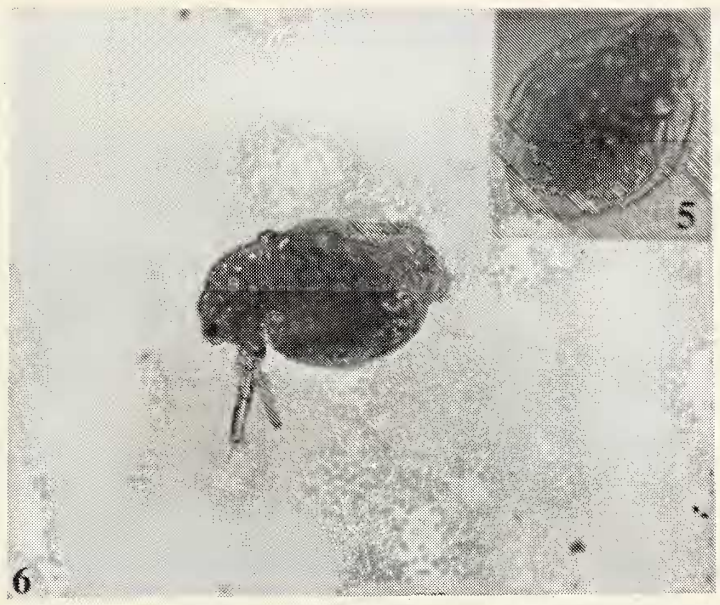
Early stage: At this stage, the newly formed eggs are spherical with a mean diameter of 0.27 mm. They are green in colour with a transparent marginal zone (Plate 1, Fig. 4).

Middle stage: At this stage the embryo is somewhat elongated. The head lobe and rudiments of thoracic legs and antennae are visible. Numerous fat globules are also present (Plate 1, Fig. 5).

Final stage: The head is distinct and the eyes are well developed. Antennae are elongated and segmented. A transparent carapace is formed







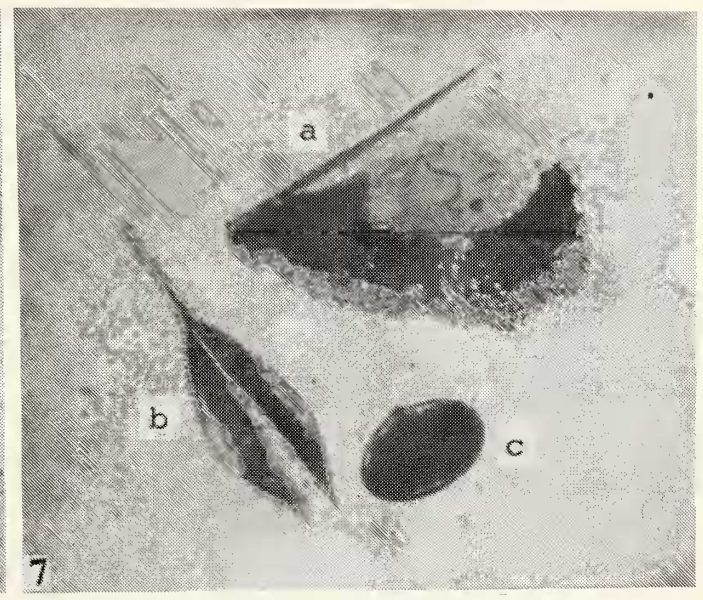


Fig. 1. Newly hatched young (0.6 mm); 2. Mature male (0.67 mm);
3. Parthenogenetic female (1.6 mm); 4. Parthenogenetic eggs (0.25 mm);
5. Developing embryo (0.304 mm) (inset); 6. Embryo with well developed antennae. (0.329 mm);
7a. Ephippium (0.63 mm); 7b. Leathery chorion (0.63 mm);
7c. Resting egg showing outer membrane. (0.27 mm).

TABLE 1
VARIATION IN SIZE AND DURATION OF INSTARS OF *SIMOCEPHALUS*

Instar No.	Mean leanth (mm)	Mean height (mm)	Eggs/brood	Cumulative no. of eggs	Instar duration in hours	Cumulative duration of instar in hrs.
1	0.615	0.42	—	—	32.15	32.15
2	0.87	0.52	—	—	32.30	67.45
3	1.05	0.67	—	—	35.30	99.75
4	1.27	0.90	4.6	4.6	38.00	137.75
5	1.46	1.05	7.2	11.8	38.67	176.42
6	1.65	1.20	14.3	26.1	41.82	218.24
7	1.73	1.33	14.6	40.7	41.58	259.82
8	1.82	1.46	25.6	66.3	36.30	296.12
9	1.90	1.50	32.6	98.9	40.30	336.42
10	2.00	1.60	35.8	134.7	39.45	375.87
11	2.05	1.65	35.2	169.9	41.82	417.69
12	2.15	1.68	37.4	207.3	43.32	461.01
13	2.20	1.72	29.6	236.9	40.28	501.29
14	2.25	1.75	32.4	264.3	42.17	543.46
15	2.28	1.76	27.5	296.8	40.30	583.76
16	2.35	1.85	22.8	319.6	46.30	630.06
17	2.45	1.87	19.5	339.1	44.35	674.41
18	2.47	1.88	17.6	356.7	46.22	720.63
19	2.47	1.88	12.6	369.3	44.42	765.05
20	2.47	1.88	7.6	376.9	46.18	811.23
21	2.48	1.88	7.6	384.5	48.65	859.88

enclosing the body appendages and postabdomen. Alimentary canal is fully extended (Plate. 1, Fig. 6). Towards the end of this stage the appendages are fully developed and the young starts exhibiting movements.

The total duration of embryonic development was observed to be 40-42 hours, after which the young were released from the brood-pouch by jerking movements of the postabdomen of the mother. This took place at any time before the mother passed through the next moult. Immediately after moulting, another clutch of eggs was discharged into the brood-pouch and the parthenogenetic cycle was repeated.

The ephippial females could be distinguished from the parthenogenetic females by their smaller size and by the absence of the blunt posterior spine on the carapace. The ephippium is a modified brood pouch formed on the dorsal half of the valves and is slightly yellowish in colour,its outer surface ornamented with a honeycomb pattern. It is somewhat triangular in shape, with a mean length of 0.63 mm and contains only the resting egg. (Plate 1. Fig. 7a). The resting egg was encased by two membranes, an inner vitelline transparent membrane and an outer thick leathery chorion. When the ephippial females collected from the stock culture were transferred to the beaker containing fresh culture medium, many of them cast off their ephippia along with the moult. The newly released ephippia floated on the surface of the medium for some time and then sank to the bottom or remained adhered to the side walls of the container.

DISCUSSION

Simocephalus acutirostratus and *S. vetulus* are the other two tropical species of the genus *Simocephalus* whose life cycles have been studied by Murugan (1977) and Kanaujia (1987)